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# **Industry Placement, Authentic Experience and the Development of Venturing and Technology Self-Efficacy**

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## **Abstract**

Many governments are keen to see enhanced levels of enterprise and entrepreneurial activity and have encouraged the higher education sector to increase the amount of enterprise education provided to students, particularly in science, engineering and technology disciplines, to prepare them for careers that advance innovation. Whilst university students derive much education and learning from within their principal discipline, significant learning occurs outside the classroom, at home, in social settings and in the workplace. This paper uses data on more than four hundred third and fourth year engineering undergraduates at four United Kingdom universities to explore the relative contribution of a range of experiences in the workplace which affect their venturing and technology self-efficacy. Experiences include different forms of workplace orientation, varying degrees of authenticity of the work they are given relative to their future careers, how students rank their performance and the presence of successful role models. Results show that authenticity, defined as a close relationship between the undergraduate's course of study, feedback on performance, and how well the students felt they had performed, are the dominant predictors of self-efficacy. The paper concludes with a discussion of the need for universities and companies to work together to pay greater attention to the quality of undergraduate placement experiences.

**Keywords:** self-efficacy; technology; venturing; industry placement; authentic experience; higher education.

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## 1. INTRODUCTION

The development and growth of a strong economy is high on the agendas of many developed nations, a large number of which have experienced marked structural shifts in economic activity over the last 30 years (Cooper 1999, Prahalad 1998). Decline in traditional industries has led to government interest in the growth of new technology-based sectors which exploit advances in fields such as electronics, biotechnology and software. In this regard, considerable attention is given to entrepreneurs who form new, high technology firms, but it is important to note that opportunities offered by new technologies are also being furthered or fumbled by large and small established companies facing volatile markets, the restructuring of supply chains and distribution channels, and the need to continue to scan for useful advances in science and technology (Chesbrough 2003, Prahalad 1998). Whether one chooses to call the organisational activity the development of “dynamic capabilities” (Teece et al. 1997), “radical innovation” (O’Connor et al. 2008), “entrepreneurial orientation” (Li et al. 2008, Lumkin and Dess 1996), “corporate entrepreneurship” (Stevenson and Jarillo 1990) or just innovation (Kirzner 1979, Schumpeter 1934), the ways that established companies pursue economic advantage in high technology sectors is as important to national economies as the appearance of new start-ups.

The emergence and success of new technology sectors in both new and established companies is inextricably linked with individuals able to recognise new opportunities and lead their exploitation (Kirzner 1979, Penrose 1959, Schumpeter 1934), and the number and location of those individuals in companies has been changing. Strategic choices, like a decision to enter new markets, were once largely initiated and led by top management (Newbert et al. 2008), and research and the development of new knowledge was dominated by internal research organisations (van de Vrande et al. 2009). As companies facing broader and more complex pressures in what Chesbrough (2003) refers to as an open innovation, company survival is more and more determined by the acquisition of a vast array of ideas, technologies and other forms of knowledge in its environment. Particularly in technology intensive companies, the capture, evaluation and subsequent communication of important information is widely distributed across company departments by employees with widely varied seniority, in what Ancona and Bresman (2007) call a distributed model of leadership. In an open innovation organisation, even relatively young engineers, who graduate with a current appreciation of technical trends and an appreciation of business opportunities, may play a pivotal role in keeping a company at the leading edge of its industry.

The success of an economy driven by technology entrepreneurship in its broadest sense will increasingly depend upon a steady flow of both entrepreneurs forming new companies, and what appears to be a far greater number of entrepreneurially-minded professionals, who as employees of established companies can track technical advances, identify important intellectual property, recognise opportunities then implement new lines of business (van de Vrande et al. 2009).

### **1.1 Sources of technical professionals for technology-intensive venturing**

In this context the United Kingdom (UK) government, like many others, has supported university-based activities with a particular concern for raising awareness and increasing understanding of enterprise among science, engineering and technology (SET) students and enabling them to develop skills and competences suited to fostering innovative applications of technology in new business ventures (Hartshorn and Hannon 2005). Whilst university students derive much education and learning from within their principal discipline (Kelly 1986, Monck et al. 1988, Oakey et al. 1990, Roberts 1991), significant learning occurs outside the classroom (Rasmussen and Sorheim 2006), at home, in social settings and in the workplace.

The effect of workplace experience, generally found in the literature (Oakey et al. 1988, 1990, Cooper 1998, Harrison et al. 2004) to be important, is widely viewed by university instructors as having a consequential impact on undergraduate readiness for the world of work. Indeed, one approach to enhancing the readiness of university undergraduates for innovative technical careers is to introduce forms of education that simulate aspects of work experience. There is growing emphasis on increasing the exposure of science and engineering students to more active and project-based learning (Okudan and Rzasa 2006, Scheibe et al. 2007) and other forms of authentic experience (Wee 2004). Given the value of experience, a role of research is to try to determine if and how activities such as industry placements prepare engineering undergraduates for innovative careers by determining what characteristics of their experience strengthen self-efficacy for venturing and, separately, self-efficacy for technology.

This paper begins with a brief overview of work placements, and addresses the literature that supports the central importance of venturing self-efficacy and its determinants for work performance and innovation. The review suggests relevant lessons that should be taken from Social Cognitive Theory (Bandura 1986, 1997), the importance of self-efficacy in predicting improved work performance in general (Stajkovic and Luthans 1998), and the central importance of entrepreneurial self-efficacy in theory and practice. Theoretical models of entrepreneurial intention

(e.g., Krueger 1993, Krueger et al. 2000, Shapero and Sokol 1982, Zhao et al. 2005) consistently consider self-efficacy a key element in the perception of the feasibility of entrepreneurship, while empirical work has shown the value of self-efficacy for predicting successful company practice among both entrepreneurs and managers (Chen et al. 1998) and entrepreneurial women in traditional and non-traditional sectors (Anna et al. 2000). The discussion then maps characteristics of work placements to the theory-based predictors of self-efficacy in Social Cognitive Theory to establish which characteristics of undergraduate work experience would be expected to predict higher levels of venturing and technology self-efficacy.

The results section then describes a study that included more than four hundred UK engineering undergraduates who had previous work placements when they were surveyed in Autumn 2004. The measures of venturing and technology self-efficacy are presented, along with the questions that characterised different elements of their work experiences, including their company orientations, the nature and difficulty of their assigned work and the presence of role models where they were placed. The results of the analysis of this survey data lead to the conclusion that work experience on average had little effect on student self-efficacy, but that when their experience had the qualities generally known to predict enhanced self-efficacy, strong differences were found. The concluding discussion addresses the fact that while a work placement can have a major effect on self-efficacy, a foundation of future innovative behaviours, those factors are all too often not present in the work placements made in the UK.

## **2. CHANGES IN THE ENVIRONMENTS OF EDUCATION AND WORK**

There is growing recognition that opportunities for individuals to have life-long careers in a single large firm are declining. Technological and economic changes are leading to a world of work where individuals will have a greater variety of careers and employers as portfolio careers become common (Henderson and Robertson 2000). This means that for many if not most people the future of work lies in small and medium-sized enterprises which often lack the resources of large companies for training new employees, leaving open the question of where young professionals will be trained. Thus, at the same time as this source of training is declining, the need for transferable skills and hands-on experience is growing rapidly. A major task for higher education is the development of employees who not only have the right skills and attitudes but also the ability to learn from experience and adapt within a dynamic and rapidly changing environment.

The UK government has responded with initiatives intended to bring universities into the mainstream of enterprise education and skills development. Because of the importance of new technologies in opening new sectors of growth, there is also a growing trend, in part driven and supported by programmes such as Science Enterprise Challenge, for universities to offer both curriculum- (education/degree-focussed) and non-curriculum-based (focussed on enterprise) activities to undergraduate and postgraduate students in SET (Galloway and Brown 2002, Kirby 2006). Knowledge and understanding of innovation and enterprise are important in helping to increase student awareness of and ability to capitalise upon opportunities in dynamic, high-technology sectors. Degree-based activities targeted at developing student knowledge and understanding of and skills/attitudes for innovation and enterprise include business and enterprise modules, in-class use of industry-based examples, video profiles of entrepreneurs (Robertson and Collins 2003), lectures by guest speakers from industry, industry-sponsored projects and company-based placements (Cooper et al. 2004). Outside the classroom many institutions have student enterprise societies/networks and run intramural, or support student participation in extramural, business plan competitions (McGowan and Cooper 2008).

Yet most individuals involved in the preparation of young professionals would agree that there are no substitutes for real work experience. To support and extend the effectiveness of traditional lecture and laboratory-based approaches to education a growing number of degree programmes, in areas as diverse as accountancy (Beard 1998), geography (Hogg 1998) and science and technology (Calway and Murphy 2002; Coll et al. 2001), provide students with the opportunity to gain degree-related work experience through short- (term/semester/vacation-long) or longer-term placements lasting for up to a year or even longer. Exposure to work within the student's subject domain provides the chance to gain real, authentic experience from applying classroom knowledge and understanding to the problems and tasks found in an industry environment. In addition to enhancing the knowledge and motivation level of students who aspire towards a particular profession, internships "can make subsequent study more meaningful" (Beard 1998, 508) and have been found to improve significantly student performance compared with those who did not undertake an internship (English and Koeppen 1993).

From a career development perspective students also develop a stronger sense of subject-related career opportunities which are consequent upon completing a degree within their field. Canter (2000) identifies the role of work placements in helping the student to develop a sense of readiness for employment, while Calway and Murphy (2002) suggest greater levels of success amongst

placement students in both securing employment on graduation and progressing within their careers compared with non-placement students. Pinquart et al. (2003) suggest that increased knowledge and understanding of the industry environment as a workplace helps to ease the transition from education to employment.

Industry work also helps students to develop the transferable skills needed in industry, such as interpersonal communication and team-working, as well as to appreciate the realities of working within an organisation. Importantly, given the opportunity to learn, practice and assess their own abilities, students with work placement experience also learn to self-assess their skills and have confidence in their ability to perform the tasks they will be expected to carry out in the future, which is to say they enhance their self-efficacy for tasks they might expect to perform in the world of work.

### **3. SELF-EFFICACY THROUGH EDUCATION AND WORK**

Innovation is advanced by those with self-efficacy, with confidence in their abilities to perform the tasks required to pursue a line of action. Self-efficacy influences whether individuals select particular careers (Lent et al. 1994), whether they persist in pursuing that career (Mau 2003), how well they perform (Stajkovic and Luthans 1998), how far they will be willing to stretch themselves and persist in taking on more challenging work (Bandura 1997), and it is consequently a well-spring of innovation. The research reported here briefly summarises the role self-efficacy plays in enabling undergraduates to pursue innovative careers.

Self-efficacy has been shown to be central to career choice and accepting careers in more challenging fields, including science and engineering. Bandura (1997) suggests that domain self-efficacy, the confidence that individuals have in their abilities to undertake a range of activities, applies to career selection. In a review of Social Cognitive Theory and career and academic interests, Lent et al. (1994) provide evidence that self-efficacy in a particular domain helps develop the individual's initial interest in a corresponding career area, followed by the selection of career paths, and then supports the higher levels of both academic performance and persistence in those domains. The self-efficacy of adolescents and young adults is important in helping to determine what fields of study they pursue (Pajares et al. 2000), and is important in understanding why some career paths are avoided by young women (Lent and Hackett 1987). Of particular relevance here, persistent pursuit of an academic path is predicted as much by self-efficacy as by actual ability in mathematics for those interested in science and engineering careers (Mau 2003, Pajares 1996).

The role of self-efficacy continues to be important once individuals have entered their careers, predicting better work performance. Stajkovic and Luthans (1998) survey 114 research reports of self-efficacy and work-related performance and show it consistently predicts higher levels of work performance across a wide variety of types of organisations and activities. In business, Barling and Beattie (1983) found that real-estate agents with higher self-efficacy in their skills had higher sales, and otherwise outperformed those with lower self-efficacy. Causal inferences about the effect of self-efficacy on work performance are supported by experimental research that uses random group assignment and the manipulation of self-efficacy (Cole and Hopkins 1995, Wood and Bandura 1989).

Based on Social Cognitive Theory, one would expect that individuals with high self-efficacy in a particular domain would both perform work tasks better, and be more innovative in the way they set about their work in that domain. If more self-efficacious individuals set themselves more challenging goals and are prepared to take on unfamiliar tasks (Fletcher 1990), then self-efficacy is expected to contribute substantially to the likelihood that these individuals will attempt innovative behaviour. Consistent with that expectation, self-efficacy has been linked in nascent entrepreneurship to behaviours such as innovation and opportunity recognition (Ardichvili et al. 2003), and entrepreneurial self-efficacy has been shown to be a central predictor of the intention to start a company. Krueger (1993), Krueger et al. (2000) and Zhao et al. (2005) have shown that entrepreneurial self-efficacy is of central importance in determining which individuals intend to start new companies. Other research has shown that among those who have started companies, the entrepreneurs with higher self-efficacy are more successful. Anna et al. (2000) find that when founders of new companies have higher levels of opportunity, planning and management self-efficacy, one finds higher sales revenues.

The literature, thus, suggests that self-efficacy is a major determinant of the likelihood that young adults will be more innovative in business, whether they will be more successful in established firms, and whether they will be founders of new companies.

### **3.1 Developing self-efficacy through authentic work experience**

Given this substantial body of evidence on the importance of self-efficacy for innovative business behaviour, this research has used measures of two types of self-efficacy, one for venturing skills and the other for technology, as outcome measures of choice for understanding why some work



experiences have far more effect on students than others. One can then map the factors in Social Cognitive Theory that predict higher self-efficacy to the corresponding elements of undergraduate work experience, and generate testable propositions about their relative importance.

Bandura (1986, 1997) describes four predictors of self-efficacy: actual performance, vicarious experience such as observing the successful behaviours of others, social encouragement and the over-coming of any anxiety of performing tasks in a new environment, and these will be considered below. First, however, one needs to call attention to the need for authenticity.

Not all work experience should be assumed to have consequential effects on the forms of self-efficacy considered here. Those performing the tasks of showing up for work and performing routine activities, such as copying and filing, may only enhance their self-efficacy for the most basic levels of employability. For work experience to increase self-efficacy for future venturing and technology applications, it must be authentic, which is defined here as being seen by the students as having required similar skills and levels of performance that they believe will be expected of them if they pursue innovative careers in engineering. It follows that for work experience to have an effect on venturing and technology self-efficacy, the experience must involve the vicarious or actual performance of venturing and technology-relevant tasks, and any social relationships will have an effect if they focus on how well the students are performing authentic tasks, and the likelihood that they can perform more advanced tasks expected of them in the future.

Authentic performance. While work experience will facilitate the acquisition of considerable knowledge and the learning of new skills, it also has the great advantage of enabling students to carry out work tasks in a real environment where their performance will be assessed both by workplace professionals and the students themselves. There is an increasing use of project-based learning (e.g., Okudan and Rzasa 2006) in teaching entrepreneurship through performance (Rasmussen and Sørheim 2006) at universities because it promotes a feeling of authenticity (Wee et al. 2004), and action-based learning (Rasmussen and Sørheim 2006) would be expected to be even more effective in an industry environment. Today, increasing numbers of UK students work on a full- or part-time basis so there are increased opportunities for them to accumulate a portfolio of work experiences against which to reflect (Robertson and Collins 2003) in addition to the experience gained through formal placements. This experience should enhance self-efficacy, but only if the work itself feels like the type of activity an engineering employee would conduct. The more the performance is felt to be authentic, like the tasks that will be encountered in the future, the

stronger the impact on self-efficacy. In an ideal environment, successful and unsuccessful performance will enable students to acquire a realistic sense of their abilities in the context of the particular world of work which they expect to enter.

University students derive much of their education and learning from within their principal discipline, directly from the core curriculum where design, content and delivery have key roles to play in influencing the effectiveness of education. In the context of university education, the focus on authenticity suggests that students will be affected by work that more closely relates to the type of industry experience they anticipate will follow graduation in their course of study. Work which is closely related to student areas of study allows them both to enhance and test their knowledge and skills in an environment many see in their futures. Direct experience leads to the development of enhanced self-efficacy through subject mastery within specific task-domains (Bandura et al. 1982, Pajares 1996.)

Social influence. The role of social influence also takes on greater importance when the environment is more like the work context they expect in the future. The performance of specific tasks in a work context enables supervisors and colleagues to provide task-specific feedback on their performance that can play a critical role in the development of realistic self-appraisal which is at the heart of enhanced self-efficacy (Trent and Schraeder 2003). Encouragement from someone known to be successful in industry will be considered useful and often more credible advice about their work performance than from an academic at the university. Conversely, if respected company employees cause anxiety through negative messages, self-efficacy can be reduced (Mantz and Sims 1981, Coll et al. 2001)

Vicarious experience. The opportunity to observe others in positive behaviours related to the business world/environment acts both as a source of vicarious learning and also provides role models which may stimulate a sense of desirability for the working environment (Scherer et al. 1989). Heinemann et al. (1992) suggest that students develop a full appreciation for the range and complexity of activities within the workplace by becoming fully integrated into that environment during their placement. In addition, the relationships which students develop with permanent staff provide them with chances to “see” the organisation through the eyes of its staff, and this is most likely to occur if the student is viewed as a co-worker. “It is the interaction between the student and the work environment, including the work performed together with the relationships established

with fellow employees that provides the best opportunity for learning” (Heinemann et al. 1992, 23-4).

This focus on how vicarious learning and social interaction influences self-efficacy is less about whether the student has a positive or negative view of a co-worker or manager and more about whether they respect a person’s judgment about the quality of their performance. The concern here is, thus, not the presence or absence of role models to emulate, but whether others in the work environment are seen to carry out their own tasks or make judgments about the student’s work that contribute to a student’s perception of his or her competence. In their investigation in New Zealand of the influence of cooperative education on the perception of students regarding skills in practical science, Coll et al. (2001) adopt Bandura’s self-efficacy construct to reveal that placements enhance self-efficacy towards these practical skills, whether or not the student possessed high or low self-efficacy at the start of the placement. They point to the general importance of observing others in work situations, and report that observation of peers was found to enhance self-efficacy as it often resulted in students assisting others, which increased their self-efficacy. Coll et al. suggest that observing experienced co-workers’ performance can, however, decrease self-efficacy and cite an exchange between a placement student and a 20-year veteran from a company development team, perceived as highly experienced in the tasks being undertaken: his comment, “Good luck son, you’re going to need it”, caused anxiety to the student who wondered what he had let himself in for. This example, however, suggests that it is not observation per se but its setting within a context of powerful social influence and emotional states which is important. As a result of the interrelated nature of these factors, how staff, who are perceived as senior, interact with students can have a powerful positive or negative impact upon on self-efficacy.

Emotional states. The fourth class of predictive forces that shape self-efficacy in Bandura’s (1986) view are the emotional states, mentioned here for completeness. While there are no measures of emotional factors in this research, it should be noted that authentic experience can remove a great deal of anxiety about what will be expected of the students in their future work, and in particular the fear that they will be expected to perform at an unreasonable level when they first arrive on the job can usually be set aside.

The literature suggests that perceived self-efficacy for performing venturing and technology tasks is a useful measure of the value of various undergraduate work experiences, and that a central characteristic of highly effective experiences is how closely the tasks they perform are perceived as

realistically representative of what they will be called upon to perform in the future. More specifically, the authenticity of the experience, task difficulty, the level of the student's performance, and the presence of and interaction with successful professionals are hypothesised to predict why one and not another work experience will lead to heightened self-efficacy for performing both venturing and technology tasks. To test this view, the research uses reports from undergraduates on the type and substance of their industry experiences and two measures of self-efficacy believed important to the persistent pursuit of technology-based innovation.

#### **4. RESEARCH METHODS**

The data used in this study are drawn from a survey designed by the Education and High Growth Innovation (EHGI) research team (see End Note) and fielded in Autumn 2004 using both paper and pencil questionnaires administered in class and an on-line version. The work began with a pilot study fielded in Spring 2004 that tested a battery of self-efficacy items intended to measure venturing and technical self-efficacy, and discovered a surprising lack of difference between those students that did and did not have industry work experience. Following the considerations discussed above, additional questions were developed about the features of work experience that were expected to predict heightened self-efficacy. The new questions were incorporated into a revised instrument, and survey data were collected from 1900 UK undergraduates in Autumn 2004. The focus here is on over four hundred engineering students beginning their third and fourth years at the Universities of Cambridge, Sheffield, Strathclyde and York who participated in the larger survey.

Presentation of the results begins with a description of the two outcome measures of self-efficacy. There follows a discussion of the relationships between these forms of self-efficacy and background characteristics, types of industry placement and the university the students are drawn from in a test for possible sources of sampling bias, identifying co-variables that need to be held constant in the subsequent analysis. Then the relationships between theoretically important characteristics of student work experiences and the measures of self-efficacy are presented. Owing to the correlations found among the background, organisational and other predictor variables, regression analysis is then used to isolate the separate contributions of the variables found to be more important in predicting the levels of two types of self-efficacy.

##### **4.1 Measuring Self-efficacy**

Bandura (1986, 1997) suggests that the measurement of self-efficacy requires items that assess the level of the individual's confidence that he or she can perform quite specific tasks, and that the tasks described have an evident level of difficulty. Using quite specific tasks means that each task will be narrow in scope and cover less of the domain of interest, but he suggests that measurement can still be successful because task-based items have the quality of generality within a given domain (Bandura 1997). Generality, as he uses it, is a belief that items in the same domain will be inter-related, allowing one to infer that an individual's self-confidence in performing one task will be correlated with confidence in performing other tasks that are part of the same, "constellation of role demands," of a given life pursuit (Bandura 1997, 51). As noted by Chen et al. (1998), this view has considerable practical value, suggesting that for the purpose of measuring self-efficacy one can develop a scale using a modest number of items that sample confidence in performing tasks in a particular domain, rather than needing to attempt an exhaustive coverage of all tasks in that domain.

The literature contains a number of efforts that approach entrepreneurship as a complex activity that involves multiple roles, requiring separate measures for the different roles. Chandler and Jansen (1992) build on earlier work on management roles (Pavett and Lau 1983) and postulate that founders have sets of perceived self-competencies organised around three roles called Entrepreneurial, Managerial and Technical - Functional. The Entrepreneurial role is seen as the competencies of opportunity recognition and the drive to take that recognition through to firm creation. Their Managerial role involves the ability to develop, "programs, procedures, evaluate performance and perform other tasks essential to implementing strategy" (Chandler and Jansen 1992, 225), and the competence to understand and motivate other people. The Technical - Functional role is fulfilled by founders who, "have the ability to use the tools, procedures, and techniques of a special field" (Chandler and Jansen 1992, 226), where the specific skills needed are determined by the industry involved. Referring to the work of Pavett and Lau (1983), they suggest that this third role would include specialised professional skills and functions such as production or accounting, and it would include the understanding of what is required to be effective in a particular line of business. Based on their analysis of the reported competencies of 134 founders of companies in Utah, Chandler and Jansen (1992) find separate empirical support for the presence of factors for the Managerial role termed human/conceptual competence, the two entrepreneurial characteristics of opportunity recognition and persistence, Technical - Functional competence, and lastly a factor called political competence that includes what many would recognise as networking competence to gain resources and the support of key individuals.

Subsequent research has been driven primarily by a search for key differences between types of entrepreneurs (Anna et al. 2000) or between entrepreneurs and general managers (Chen et al. 1998, De Nobel et al. 1999). As noted above, Anna et al. (2000) develop metrics for self-efficacy to identify differences between women entrepreneurs in traditional and non-traditional business sectors, basing their research on responses from 143 women business owners in Illinois and Utah. They find that there are separate clusters for self-efficacy for opportunity recognition, human/conceptual competence, formal planning and economic management, matching up reasonably well with the first Entrepreneurial and Managerial role sets identified by Chandler and Jansen (1992).

Chen et al. (1998) and DeNoble et al. (1999) made other choices of specific tasks to tap self-efficacy, and arrive at somewhat different results. Chen et al. (1998) develop a set of 26 items that they believe represent the domains where individuals need self-confidence in their abilities to be entrepreneurs, and report on data from 140 MBA students and 175 small business owners and executives in the northeastern United States. Their analysis leads them to conclude that the entrepreneurial roles are Marketing and sales, Innovation (including new ideas and products as well as new ventures), Management (planning, goal setting, organisational design), Risk-taking (decisions under uncertainty, working under pressure) and Financial control (development of financial systems, analysis and cost control).

De Noble et al. (1999) similarly focus on what was seen as unique to entrepreneurship, starting by asking entrepreneurs about the critical issues they had faced starting companies. The items were first screened, keeping those viewed as essential to entrepreneurship, and the remaining items were used in two studies using data collected from 272 undergraduates taking business courses and 87 MBA students in a large public university in the southwestern United States. They find that the self-confidence to perform entrepreneurial tasks cluster around Developing new product and market opportunities, Building an innovative environment, Initiating investor relationships, Defining the core purpose, Coping with challenges (stress, persistence and dealing with the unexpected) and Developing human resources.

Taken together, these elements of self-efficacy are quite similar to other studies that do not use the self-efficacy construct but are nonetheless concerned with what is deemed necessary (rather than what is unique) to entrepreneurship. Serarols-Tarrés et al. (2006), for example, arrive at a set of entrepreneurial characteristics that include skills that are needed in any newly formed business unit

as well as start-ups, including the ability to select the right colleagues, have the right creative and marketing skills, negotiate payments with suppliers, and get the right funding.

Following Chandler and Jansen's (1992) work, the view here is that the first role of importance where entrepreneurs need to have a high level of confidence is knowing their product and market. While this role is not given prominence in other self-efficacy research, it is found in other lines of research. Serarols-Tarrés et al. (2006) list factors that involve the ability to use the knowledge, skills and experience that are involved in the particular arena of one's new venture. These include having experience and knowledge about the industry, products and market one is entering, having thoroughly studied the market from the customer's perspective and the compatibility of the venture with entrepreneurs and their product experience. Another example is found in Chorev and Anderson (2006), who place an emphasis on having comprehensive acquaintance with the market and a personal acquaintance with customers as important predictors of success. For technology-intensive companies one might add the need for professionals who have a deep understanding of the theory and applications of the particular technologies being considered.

Looking at the other roles, one can see this research as supporting a quite broad view of the Management task domain. While differing in detail, the studies reviewed here seen together have touched on most of the functions of general management, including strategic visioning, planning, marketing and sales, financial systems and management, cost control, organisational design and management and human resources.

As for tasks thought to be a part of a self-belief that one can become an entrepreneur, all four studies give a central place to opportunity recognition. One might note, however, that Chen et al. (1998) include New venturing and ideas, New products and services, and New markets. Opportunity recognition, thus, includes opportunities that are also seen and exploited by individuals being innovative in the firm. Other tasks said to be the special concerns of the entrepreneur such as persistence include working under stress and risk-taking, but the need for self-confidence in these areas is not unique to entrepreneurs. Only the role of identifying creating and maintaining investor relations role (De Noble et al. 1999) can be said to be a competence that is almost entirely in the domain of founding new companies.

Measuring venturing self-efficacy. The measurement strategy for this research follows Chandler and Jansen (1992) to develop scales that broadly represent the Managerial, Entrepreneurial and

Technical - Functional roles. The items are drafted to include leadership of major innovation rather than focusing narrowly on the formation of companies. Consistent with the work of Chandler and Jansen (1992) and Anna et al. (2000), short task descriptions were written that involve self-confidence for one's ability to engage in opportunity recognition, business plan writing, project management, managing human resources, marketing a new service, and estimating costs of a new project. Consistent with Chen et al. (1998), there is an item on sales of new products, and an item on working with suppliers is an instance of using relationships (Chandler and Jansen 1992) in the area of production that is a management activity in Chen et al. (1998). Rather than adding items that sought to differentiate entrepreneurs from managers, the items were all written in the context of skills needed for the launch of consequential innovation that would require the performance of tasks including recognition and valuation of new opportunities, developing a new business plan, estimating costs of new projects, marketing and selling new products, and personnel selection (see Table 1).

< Table 1 near here>

The Technical-Functional Role. A scale consisting of student self-confidence in performing tasks required to use new science and technology applications is offered as a measure of competency of engineering undergraduates to perform the Technical – Functional role in innovation (Chandler and Jansen 1992). Items were written to measure self-confidence in performing tasks that included understanding the limits of technology, translating user requirements into technical requirements, and leading a team of technical professionals, with the expectation that they constitute tasks that the undergraduates would be expected to perform if they were to be successful in work with technology. To see if the science-oriented skills would be separate or part of this construct, items were also included on scientific testing and moving from science concepts to applications.

The responses of third and fourth year UK engineering students in the EHGI survey are used to test for underlying dimensions of these self-efficacy items. When the responses are subjected to rotated factor analysis, two rather distinct components emerge, with some items loading on both. The first includes both the Managerial and more Entrepreneurial items like opportunity recognition which is termed venturing self-efficacy. The second consists largely of items that involve technology applications (note bolded numbers, Table 1), supporting the view of Chandler and Jansen (1992) that there is a separate and distinct Technical - Functional role. They over-lap when the task involves both venturing and technology self-efficacy, as shown by four items that load on both components. For example, the item on translating user needs into technical requirements, an



activity involving marketing information and technical specification, has a loading on the venturing component of .526, but it also loads .563 on the technical component. These items are dropped from the analysis in order to have scales based on the items that capture the distinctness of the domains, following the rule that a scale should be created with items that have a component loading of .6 or higher and load less than .4 on any other component. The seven venturing tasks that remain are then combined in a scale that has a Cronbach's alpha coefficient of .907, offered here as a measure of business venturing self-efficacy that is not limited to tasks tied to the founding of new companies. Four tasks involving technology constitute a scale with an alpha of .866, which is accepted for the purpose of this work as a measure of technology self-efficacy.

The validity of this measure of venturing self-efficacy can be tested by relating it to a measure of entrepreneurial intention used on the questionnaire and described in other research (Cooper and Lucas 2006). Some of the best evidence that a scale measures self-efficacy is based on its predictive power: "Self-efficacy measures gain validity from their demonstrated success in predicting the effects specified by the social cognitive theory in which the efficacy factor is embedded" (Bandura 1997, 45). The relationship between entrepreneurial self-efficacy and intention is well established (Ajzen 1991, Boyd and Vozikis 1994, Krueger 1993, Krueger and Brazeal 1994, Krueger et al. 2000, Shapero and Sokol 1982, Zhao et al. 2005), and as would be predicted, the seven items going into this scale all correlate with the intention measure, with  $r = .409$  for opportunity recognition,  $r = .362$  for selling a brand new product and  $r = .353$  for placing a value on a new venture. The lowest correlations between an item and entrepreneurial intent are  $r = .312$  for cost estimation and  $r = .289$  for recruiting the right staff. All seven relationships were statistically significant, with  $p < .001$  in each case. The scale made up of these seven items correlates with the intention measure ( $r = .424$ ,  $p < .001$ ).

While venturing and technology self-efficacy are correlated (see Table 4:  $r = .595$ ,  $p < .001$ ), it is a conclusion of some importance that the confidence of these engineering undergraduates in working in new ventures, including finance, marketing and sales, is not the same phenomenon as confidence in one's perceived ability to work with technology applications. This conclusion that they are separate variables is strengthened by further findings below showing that they relate differently to several background and experience variables.

## **5. GENERAL RESULTS**

The first result (Table 2) is that there seems to be only an inconsequential difference in levels of self-efficacy as a function of different types of work experience. The third and fourth year engineering students who report no work experience at all in the past year feel that they could perform the venturing tasks with on average a 50.7% level of confidence. Those who had work experience in the past year in a university or other educational setting report a confidence level of 51.8%; those who worked in government authorities, charities and other public organisations report 54.1%; and the much larger group who worked in industry had a 52.5% level of confidence in their venturing skills. There is a similar pattern for their confidence in their ability to carry out efforts involving technology applications, with students with no recent work experience saying they are on average 53.1% confident they can design and build something new that performs close to their design specification, grasp the best ways to use a new technology, and perform the other technical elements in this scale. Those with industry work experience report an average confidence level only slightly higher at 55.4%, with the levels of those who worked in educational organisations (52.9%) and authorities and charities (53.8%) falling between. Just the fact that undergraduates have worked in industry does not mean the experience has had much effect on them.

<Table 2 near here>

## 5.1 Background Factors and Self-efficacy

Given a popular belief that industry experience has a strong effect on undergraduates, it seems likely that there are, indeed, undergraduates who return to the university from work placements in industry who exhibit more confidence and a deeper understanding of business and technology. The task becomes the identification of the factors that lead some students to greatly benefit from industry work experience, whilst others do not. To serve that purpose, a filter is used to select out from the third and fourth year engineering students only those who had worked in business or industry organisations in the past year, a total of 256 students. To ensure that any industry effects were not diluted by those who might have worked in more than one kind of organisation, only those who said that they had spent the most time as an employee in industry were included.

Types of industry experience. The first concern is whether the type of industry work experience matters: Did the students have part-time work, summer placements and/or work during the academic year. The latter includes both students who worked in a company for a full “sandwich” year, and those who worked full-time for a shorter yet still extended period of time during the academic year. Only a small number of the students captured by this survey, accounting for 4.7% of the total, worked full-time for four or more months in the previous academic year in a company.

The largest group (77.3%) had been employed in summer work in a company, and half (52.0%) had part-time work. The sum of these percentages shows that roughly one in three of the students had more than one industry experience during the past year. An analysis of the over-lap found that most of those with part-time work had done summer work as well, so that the proportion of students who had only done part-time work was 21.9%.

Looking for any effects that might be attributed to these different kinds of work placements, three dummy variables (e.g., part-time work versus other) are created and correlated with the two measures of self-efficacy. The relationships between each of the measures of self-efficacy are seen in Table 3 for sandwich year placements ( $r = .047$  and  $-.039$ ), summer work ( $r = .076$  and  $.066$ ), and part-time work ( $r = -.003$  and  $-.072$ ). The types of work the students have experienced in and of itself do not predict differences in levels of self-efficacy.

<Table 3 near here>

Background factors. These engineering students are largely male (79.3%), and a substantial number come from homes where their father owns a business (34.4%). The analysis that follows might, therefore, need to control in some way for background and self-selection effects. Gender has been shown to have important effects on career-related self-efficacy in science, engineering and maths (Betz and Hackett 1983, Mau 2003), and that same difference is found among these students. Table 3 shows that male undergraduates are somewhat more likely to feel confident of their ability to perform venturing tasks ( $r = .178$ ,  $p < .01$ ), and substantially different in their confidence to work with technology applications ( $r = 0.259$ ,  $p < .001$ ). Having a father who owns a business has similarly been found to be important in Britain (Tsorbatzoglou et al. 2001) and elsewhere (e.g., Carayannis et al. 2003), and a similar result is found here for venturing self-confidence. While having a father with this occupation is not found to be significantly related to technology self-efficacy ( $r = .116$ , not significant), individuals with entrepreneurial fathers have higher levels of venturing self-efficacy ( $r = .189$ ,  $p < .01$ ). The self-selection of individuals with these background characteristics must be taken into account to have an accurate understanding of the effects of industry experience.

A contextual factor of concern is the possibility that there are substantial differences among the universities included in the study. The possibility, and the associated problem that the results might be biased, is increased because half (49.6%) of the students in this analysis were enrolled at the University of Strathclyde. Strathclyde is different by reason of being in Glasgow, drawing largely

from a Scottish national educational system and culture somewhat different from that of the three English universities. Strathclyde receives less public research funding and ranks less highly in tables of UK universities. Are the Strathclyde students offered different work experiences that affect their subsequent levels of self-efficacy? When one creates a variable that allows the comparison of students from Strathclyde with those from the Universities of Cambridge, Sheffield and York, and relates it to the levels of self-efficacy, no differences are found ( $r = .017$  and  $-.078$ , neither significant). There are no meaningful differences in levels of the types of perceived self-efficacy studied here among the four universities that could affect the conclusions drawn below.

## **5.2 Elements of Industry Work Experience and Self-efficacy**

The literature on self-efficacy and the content area of venturing and technology led the research design to include the study of orientation programme elements that would strengthen an understanding of industrial organisations, the authenticity of the experience, and how much difficulty was encountered. Given the central place of performance and feedback in Social Cognitive Theory, a question was asked as to how well the undergraduates felt they had performed and whether they had received comment on their performance. Lastly, the study ascertained whether the students had seen individuals who could have been a source of vicarious learning, and the frequency with which they had personal contact with them.

A. Orientation showing where a student's unit fits. Several questions were asked about company orientation programmes and activities. Authenticity involves both the nature of work and how it fits in the larger context. If individuals are given a good understanding of how companies function, and how the student's work contributes to the company, it may add to the student's venturing self-efficacy. A third (35.8%) report it had been explained to them how their organisational unit where they worked fitted into the broader company.

B. Rotation through business units. An effort was made to test for another possible source of contextual understanding, the opportunity to see in some detail how various departments and offices operate. A question asked simply whether the student had been moved in rotation from one business unit to another, a not uncommon practice used by companies to expose students to different company activities. Of the students studied here, 32.7% said they had been rotated around to work in different departments.

C. Authenticity as closeness to course of study. The feeling that a work experience is like what one will encounter in the future provides a context that allows placement students to test their knowledge and skills to see if they are ready for a particular work domain. The fact that 45.1% say their industry work bore no relationship to their university course of study may go a long way in explaining why industry experience in general does not make a difference in these engineering students' self-efficacy. Just over a third (35.3%) felt their work had been directly related to their studies, and only 19.1% fell between saying there had been "some relationship".

D. Difficulty. An important element in Social Cognitive Theory is the notion that learning and self-confidence follow from individuals stretching their capabilities to accomplish increasingly difficult tasks. So long as the students were not pushed well beyond their capabilities, they would be expected to have higher self-confidence if they had faced more difficult but still achievable tasks. The responses suggest that 31.9% who said the work was well below their level were not challenged at all. Another 22.0% said the work was somewhat below their level, and 32.7% say it was about right for their level. Those who would be expected to benefit the most are the 12.6% who were pressed with a difficulty above their level. Only 0.8% said they had been given work well above their level.

E. Performance. Successful performance of tasks is central to the development of self-efficacy, and it is found that the students in this study perceive themselves as having done rather well. When asked to rate how well they had done in their work, none said they had done a poor job, only 1.6% thought their work had been less than adequate, and a small proportion of 11.4% feel they had done an adequate job. With 56.7% saying they had done a good job, and 30.3% saying an excellent job, one can conclude that the students' own views of their performance are generally very positive.

F. Received comment. Self-perception alone is not likely to be sufficient for university students. Having confirmation of how well one has performed is the primary way individuals develop their own ability to understand what level of performance is expected, and how accurately they perceive their own ability. It would appear that more UK companies provide this feedback than not, with 64.2% of the students saying they had received comments about their performance.

G. Observable performance by others. Two of the factors that Bandura (1997) suggests are central to the development of self-efficacy are vicarious performance and social influence, and both would lead one to predict that the presence of successful individuals during the student placements would

play a central role in the growth of self-efficacy. Such experiences may introduce information or techniques new to the observer (Scheibe et al. 2007), or if not new, approaches that would not have otherwise been thought of as relevant and useful. Watching co-workers in their work environment in and of itself shows the student what skills are valued, and what levels of those skills constitute high quality performance. To assess vicarious learning from observing tasks being performed well, the question was asked if the responding students had observed someone in the company who was “effective and successful”; two-thirds (69.1%) of the students said they had seen such a person.

H. Social influence. While vicarious learning can be brought about through observation alone, if the student has personal contact with individuals seen to be successful, an even larger effect is expected. To estimate the potential level of social influence and learning guided by others, the students were asked how often they spoke with these successful individuals. Of those who reported having observed someone successful, three quarters of the students (76.4%) reported that they spoke with these highly effective performers several times a week, showing access and a significant level of social communication. Another 15.2% said they spoke with the person they identified as effective and successful around once a week, while 5.1% said they spoke once or twice a month and 3.4% said they almost never spoke with the successful individual they identified.

When asked who this successful person was, the student’s supervisor was named by 39.8%, the most common response, and another manager or executive was identified by 31.3%. The fact that the students appear to respect figures that hold some authority, and are in relatively frequent contact with them, leads to the view that performance feedback would have been taken seriously, providing strong feedback for the development of accurate self-appraisal.

### **5.3 Relationships with Venturing and Technology Self-efficacy**

The responses to these questions are then correlated with the two self-efficacy scales. The first results (see Table 4) suggest that authenticity as defined as closeness to one’s course of study is the most important predictor variable by a considerable margin. It correlates with venturing ( $r = .218$ ,  $p < .001$ ) and technology self-efficacy ( $r = .300$ ,  $p < .001$ ). Self-efficacy for venturing ( $r = .153$ ,  $p < .05$ ) and technology applications ( $r = .178$ ,  $p < .01$ ) are both higher when related to job rotation during their placements; and both are higher ( $r = .176$ ,  $p < .01$  and  $r = .142$ ,  $p < .05$  respectively) when the students had received comments about their performance. Only venturing self-efficacy is influenced by organisational knowledge being presented at orientation, adding to the view that the two types of self-efficacy are separate concepts. Orientation programmes show how the student’s

organisational unit fits within the company ( $r = .167, p < .01$ ) and having more frequent conversations with someone seen as being successful in the company ( $r = .129, p < .05$ ) both relate to venturing self-efficacy.

<Table 4 near here>

The correlation matrix also reveals that these predictor variables are sometimes strongly inter-related. For these engineering students, if the work is close to their course of study, it is seen as more difficult ( $r = .514, p < .001$ ), there was more rotation around the organisation ( $r = .218, p < .001$ ), and they were more likely to see ( $r = .233, p < .001$ ) and talk with someone successful in the company ( $r = .214, p < .001$ ). These last results suggest that difficulty as judged by these engineering students refers disproportionately to the difficulty of technology-oriented tasks, rotation in technical organisations, and observing someone successful in technical organisational contexts, an inference that provides useful insight into results found below.

Other relationships of note include the fact that companies that provide an explanation of how an individual fits into the larger organisation were also the organisations that were more likely to have provided feedback on performance ( $r = -.218, p < .001$ ). By far the strongest relationship of  $r = .878$  is found between having observed a successful performer and having talked with that individual, an artefact resulting from the fact that there is a large number of students without a high performing individual to observe will of course have had no discussion with one. Taken together these inter-relationships make it difficult to isolate the separate contributions of these variables on self-efficacy, a task that requires regression analysis.

#### **5.4 Regression Analysis**

The advantage of regression analysis for the purposes here is that it partials out over-lapping variation in the correlations to show the separate contribution of each variable. When stepwise regression is used, it also allows one to test if one set of variables adds significant explanatory power above and beyond a prior set. The analysis that follows shows which elements of industry experience predict heightened self-efficacy above and beyond that predicted by key background factors.

Predicting Self-efficacy for Venturing. Table 5, Column A is offered as a test of the independent effects of the variables used in this study. Note that because the units of measurement used here vary from one variable to another, the regression coefficient  $b$  can be quite misleading. Instead the

focus is on the standardised beta coefficients so that they can be directly compared. The first step shown as Model A1 represents the aggregate effects of the two background characteristics, being male and having a father who runs his own business, on venturing self-efficacy. Together these background factors explain 6.7% of the variance ( $p < .001$ ) and both men ( $\beta = .172, p < .01$ ) and father's occupation ( $\beta = .183, p < .01$ ) are independent and statistically significant predictors of venturing self-efficacy. With this baseline established one can take a second step and test the importance of the contribution of industry experience represented as a set of variables added to Model A2.

<Table 5 near here>

This model increases the explained variance by an additional 11.9% ( $df\ 8, 228, F\ change = 4.148, p < .001$ ), bringing the total explained variance to 18.6% ( $F = 5.195, p < .001$ ). Clearly then, industry experience is a consequential predictor of venturing self-efficacy above and beyond these background factors. Examination of the beta coefficients then allows an investigation of the relative effects of the variables in the model. Like the results of the correlation analysis, difficulty of work is again found not to be a factor for venturing self-efficacy, but notwithstanding the correlations found above, other factors can also be set aside. When the effects of the industry experiences are partialled out, having seen someone effective to serve as an exemplar by itself does not predict venturing self-efficacy ( $\beta = -.057, n.s.$ ), nor does having a placement experience that involves the undergraduate having assignments that rotate through the organisation ( $\beta = .078, n.s.$ ).

As predicted, however, authenticity and a positive self-evaluation of performance ( $\beta = .176$  and  $\beta = .147$  respectively, both with  $p < .05$ ) do predict venturing self-efficacy, with orientation on how the student's assigned unit fits in the larger organisation and receiving performance feedback also providing some contribution.

To take this investigation further, a fitted model (Table 5, Column B) is then recalculated without these three variables. The two background factors are again run as a baseline Model B1 with the same results. Then in a second step, the remaining five variables are introduced. The second step completes Model B2 with a  $R^2$  change of 11.2%, only trivially different from the 11.9% explained by the original Model A2, confirming the expectation that the excluded variables have little predictive consequence.



Again using beta coefficients, the beta coefficients in Model B2 can be compared to look again at the comparative effects of the background and industry variables on venturing self-efficacy. Having a father who runs his own business ( $\beta = .197, p < .01$ ) and the authenticity of the work experience ( $\beta = .186, p < .01$ ) continue to be the most important predictors. Given that the survey respondents here are all studying a field of engineering, this is to suggest that undergraduates in engineering develop some business venturing skills when they are given engineering placements. As theory would suggest, self-efficacy arises from successful performance. How well the students felt they have performed relates to venturing self-efficacy with a  $\beta$  of .149 ( $p < .05$ ). Then the value of having comments on one's performance so it can be better evaluated and improved upon is reflected in the somewhat weaker  $\beta$  of .116 ( $p < .05$ ), showing that comments on performance contribute to self-efficacy. How often the students talked with someone who was seen as successful and effective has only a marginally significant predictive effect ( $\beta = .072$ ).

The other significant finding is that orientation programmes can influence venturing self-efficacy, with an interesting implication for entrepreneurship education. For the predictor variable knowing where one's work unit fits into the larger environment, a  $\beta = .124$  ( $p < .05$ ) suggests that self-efficacy is enhanced by an understanding of context independent of gender, a father owning a business, task performance, task difficulty and observing the successful performance of others. Perhaps such skills as recognising when an idea might support a new venture is facilitated by a deeper understanding of how organisations function, but whatever the mechanism, this result suggests that organisational knowledge in and of itself can have an independent effect on venturing self-efficacy.

Predicting Self-efficacy for Technology Applications. The exploration of self-efficacy for technology applications begins with Table 6, Model C1. Again a first step is offered showing the effects of the two background variables which together have an explanatory power of  $R^2 = 7.0\%$ , similar but not exactly the same as the results found above because of two cases with missing data. An examination of the beta coefficients, however, shows that the far larger predictor of technical self-efficacy is gender ( $\beta = .242, p < .001$ ). While it is left in the continuing analysis for reasons of consistency, having a father who runs his own business has only a marginal effect ( $\beta = .086, n.s.$ ), suggesting that this background characteristic plays a rather minor, if any, role in predicting technology self-efficacy. One might mark the fact that the two types of self-efficacy are related differently to these key background predictors.

<Table 6 near here>

In the second step, the full set of industry experience variables is again introduced in Table 6, Model C2, and there is strong statistical evidence that industry experience is an important predictor of technology self-efficacy independent of gender and a having a father who runs his own business. The change in explained variance is 13.6% ( $df = 8, 230$ ;  $F \text{ change} = 4.946$ ;  $p < .001$ ). When background and industry experience as represented by these variables are considered together in Model C2, these variables account for a total explained variance of 20.7% ( $df = 10, 230$ ;  $F = 5.986$ ,  $p < .001$ ).

Inspection of the beta coefficients again supports the importance of the theoretical predictors of technology self-efficacy. In addition to gender, the authenticity variable is again a dominant predictor of higher self-efficacy ( $\beta = .209$ ,  $p < .01$ ). Other predictors that contribute to the model with betas that are greater than .1 are the undergraduates' views of how well they performed ( $\beta = .114$ ,  $p < .1$ ), and the difficulty of the work ( $\beta = .113$ , n.s.). Given the fact that, as reported above, most of the students have reported that they performed their work adequately or well, one sees here limited support for the view that self-efficacy arises from overcoming difficulty. The last predictor variable to be carried over into the next model is the fact that an individual's work placement experience involved rotation through different company departments ( $\beta = .100$ ,  $p < .1$ ).

A significant contributor to the venturing self-efficacy model, learning how the student's group fits in the company, makes no positive contribution to technical self-efficacy ( $\beta = -.056$ , n.s.) and is not included in the fitted model. Also deleted from the next model are the variables representing comments about performance ( $\beta = .064$ , n.s.), and how frequently the student spoke with someone who could serve as a role model ( $\beta = -.127$ , n.s.). In a step not shown, an intermediate model was calculated, and the beta that results for the question observing someone who is effective, and who could then serve as a role model, fell from the .178 value in Model C2 to a value of .072. After deleting that variable as well, a new fitted model in Table 6, Column D was calculated.

When the two background factors are introduced as a first step in Model D1, the results are virtually identical with those in Model C1 and the explained variance is 7.1%. When Model D2 in Table 6 is calculated after adding four industry variables, the results are an increase in explained variance of 12.1% ( $df = 4, 235$ ;  $F \text{ change} = 8.841$ ,  $p < .001$ ). This reduced set of variables includes authenticity, difficulty and performance, showing that three variables developed about industry

experience following the general precepts of what predicts self-efficacy are key in predicting levels of technology self-efficacy. The fourth variable of the undergraduate reporting a placement that involved being rotated through departments also makes a modest contribution to the model ( $\beta = .106, p < .1$ ). Rather than seeing rotation as a broadening of business knowledge, one might speculate that this result suggests that rotation of engineering undergraduates largely involved technical departments, and may be about students having an opportunity to see a variety of technology roles and activities.

## **6. DISCUSSION**

Several cautions about this analysis should be kept in mind. There are several potential sources of bias that could enter the study because no effort was made to balance the representation of different types of work experience, or the representation from the participating universities. It could be argued that the lack of general benefit found here from industry placements is a result of a bias in the distribution of the three types of work placement included in this study. A particular concern is the possibility that sandwich work placements in the academic year are much more likely to have a substantial positive effect than other types of work experience. While the sandwich year students in this study were not different from those with other work experiences, they were few in number and may not be representative of sandwich year students in general. One should, therefore, be cautious in assuming that experience in extended placements during the academic year has on average little effect on self-efficacy.

More generally, any reader concerned with the first conclusion, that industry placements are not all as effective as many believe, might conduct a simple but interesting test of asking if a programme they know well and believe to be successful has characteristics found here to predict higher self-efficacy. If the answer is yes, then it would appear to be an exception where better results are predicted by this research.

Measurement. Because the survey was given to undergraduates in a variety of engineering fields of study, several of the predictor variables are broadly drawn, and it must be kept in mind what self-efficacy does and does not measure. In particular, the predictor authenticity of experience is measured by whether the work relates to the undergraduate's course of study. That involves some necessary assumptions that individuals will be strongly biased toward learning the nature of work in their fields of study, and will be less influenced by otherwise meaningful work of another kind. The results certainly confirm the pivotal importance of work being related to self-efficacy, but it would

have been better if authenticity could have been defined in more detail. Some indication regarding the positive or negative impact of observing and interacting with role models would also have been instructive, given earlier comments regarding the work of Mantz and Sims (1981) and Coll et al. (2001).

Outcomes. There are of course other important outcomes that one might assess to see if they are affected by industry experience. While it is generally true that individuals have a certain self-awareness about their actual skill levels that is reflected in self-efficacy, ideally one would offer data on both observed skills and self-efficacy. The reader should keep in mind that no measure of actual skills is available for this study.

Gender effects. There are an increasing number of programmes targeted at UK school children to engage them in SET activities, some focussed specifically on girls, but there does not appear to be much recognition of the importance of self-efficacy for SET domains. The women in this research have persevered through the study of science and mathematics in secondary school, competed successfully to enter university engineering courses and then completed two or three years of university-level engineering studies, yet they still have substantially lower self-efficacy than men with the same experience. A likely consequence of these lower levels of self-efficacy for technology applications is that a disproportionately lower number of these women are likely to persist in technology-oriented careers (Mau 2003). Going further, what we know of self-efficacy suggests that if women do persist, they are less likely to be leading innovators in their fields. The Global Entrepreneurship Monitor reports that “Men are approximately twice as entrepreneurially active as women” in the UK (Tsorbatzoglou et al. 2001, 12), and Anna et al. (2000) show that of the women who start a company, those with lower self-efficacy will have less success. Given the importance of authentic experience in the development of self-efficacy, placing technically educated women in industry work related to SET careers should be given a high priority.

Differentiated self-efficacy. The factor analysis and the results that follow have a general implication for education of innovative engineering professionals in terms of the content of courses and modules, and funding programmes that support them: while related, venturing self-efficacy is not the same thing as technology self-efficacy. In these four UK universities the development of the skills and self-confidence in the one form of self-efficacy is not necessarily followed by enhancement of the other. Looking at the regression data, they are influenced quite differently by the background factors of gender and family entrepreneurship. Learning about organisations in

orientation and then at work enhances venturing self-confidence, but not surprisingly does little to strengthen confidence in technology skills. Perhaps one should think more carefully about programmes that teach general entrepreneurship for engineering students without attending to skills development specific to technology-based venturing.

## **7. CONCLUSION**

Addressing not just start-ups but all companies in technology-intensive industries, Teece et al. (1997, 523) suggest that “It is well recognized that how far and how fast a particular area of industrial activity can proceed is in part due to the technology opportunities before it.” The exploitation of new market opportunities created by advancing technology requires engineers who can work effectively with professionals in finance, marketing and other fields (Chorev and Anderson 2006, Serarols-Tarrés et al. 2006), and one of the more successful forms of learning from both theory (Bandura 1997) and practice (Rasmussen and Sørheim 2006) involves the performance of tasks similar to those to be encountered in the future.

If authenticity of experience is important to the development of self-efficacy, actual work experience which tests one’s skills and results in performance feedback in an industry environment could be the most important experience engineering students will have until they leave the university. On the one hand this seems to be widely recognised by the number of students taking a “gap year”, working a year before entering university, and other placement offerings: Jones (2004) estimates that in the UK there are between 200,000 to 250,000 young people between the ages of 16 and 25 who undertake gap years of one kind or another, and that number is rising. Yet the first finding of this research is that on average industry work does not automatically contribute to engineering student confidence in their venturing and technology applications skills.

It would appear that placements are more successful when students have some skills to test, suggesting that a programme begins with preparing students for placement so that they have skills to offer. This view suggests that mid-university and post-graduation placements would be more beneficial than “gap year” or other early placements in science, engineering and other fields that require consequential education. Findings suggest that to realise some of the highest levels of personal and professional development, the students should be placed in companies and positions where the work is authentic, related to a career track that holds some interest for them. They should be given meaningful and achievable tasks, but those activities should encourage the placement students to reach beyond their current level of skills. A final, but vital part of the process is that

students should be provided with feedback on their performance, during the period of their placement as well as at the end, so that there are opportunities to reflect upon and modify current performance and engage in new behaviours and activities whilst still in the placement.

For their part, companies recognise a number of key benefits arising from placements. They serve as extended, 'informal interviews' that benefit both company and student, and provide an invaluable window on sectoral career opportunities both within the company in which they are placed and in other organisations. On a wider level, placements play an important role in the development of a pool of skilled labour essential for innovation and industry growth.

If an incentive is needed to capture national attention for a review of the role of undergraduate (or graduate student) work experience, an immediate benefit might be a reduction in the number of engineering students leaving the field for other pursuits. Many graduates from SET disciplines do not pursue careers in related fields; a large number in the UK, for example, secure employment in the financial services sector where their high levels of numeracy are well rewarded. In the UK it is clear that the trend of technically-trained graduates leaving their fields will inevitably represent a significant loss to the economy (Roberts 2002). Yet there is evidence that engineering students who study on programmes with work placements show higher levels of employment six months post-graduation than those who are on programmes with no such period of authentic work (see for example, Bowes and Harvey 1999). Using industry experience in technology-dependent firms to enhance student understanding of technology-related work, and to increase their self-efficacy that they can perform the tasks such work involves, seems an obvious opportunity to enhance the numbers of those who remain within the field.

The open question is what roles are to be played by the university, industry and government policy and funding in finding attracting, educating and providing the practice necessary to prepare young engineers for innovative careers at a sufficient scale to matter. Many large companies that once were major providers of employee training have been cutting back on their programmes, not expanding them, particularly in recessionary times. Indeed, a 2008 survey of 120 training and development managers revealed that 44% expected their budgets to be cut (Charlton, 2008) whilst results of a recent survey in the US showed that corporate training spend had declined by 11% ([www.elearningcouncil.com](http://www.elearningcouncil.com)). Companies may not have appropriate tasks for students to perform, and good ideas for student work have a way of disappearing under the pressure of day-to-day business. At the university, the engineering courses are already demanding to the point of

discouraging students, and most engineering departments in universities are already facing more competing demands for student time than they can accommodate. Successful university-led placement programmes are time-consuming and should not be mounted on a large scale by the faint-hearted. Such programmes must be well-resourced and supported and it is often difficult for universities to allocate the resources on the scale that is needed.

Yet it remains that competitive economies will require engineers with strong skills in product design and new business development both in start-ups and in established technology-intensive companies. Despite the barriers, it is difficult to imagine how one could prepare the many thousands of engineering professionals who will be needed to produce competitive products and services for a world of open innovation and volatile technology-based markets without more successful industry placements than have been found here.

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**Table 1 - Factor Analysis of Self-efficacy Item Pool**

For each statement circle a number from 0 (0% Not at all confident) to 10 (100% Completely confident) to indicate how confident are you that you could perform that skill or ability now.	Component	
	I	II
Know the steps needed to place a financial value on a new business venture.	<b>.819</b>	*
Pick the right marketing approach for the introduction of a new service.	<b>.801</b>	*
Work with a supplier to get better prices to help a venture become successful.	<b>.798</b>	*
Estimate accurately the costs of running a new project.	<b>.735</b>	*
Recognise when an idea is good enough to support a major business venture.	<b>.734</b>	*
Recruit the right employees for a new project or venture.	<b>.703</b>	*
Convince a customer or client to try a new product for the first time.	<b>.621</b>	*
Write a clear and complete business plan.	.595	.414
Convert a useful scientific advance into a practical application.	*	<b>.838</b>
Develop your own original hypothesis and a research plan to test it.	*	<b>.811</b>
Grasp the concept and limits of a technology well enough to see the best ways to use it.	*	<b>.766</b>
Design and build something new that performs very close to your design specifications.	*	<b>.736</b>
Lead a technical team developing a new product to a successful result.	.417	.709
Understand exactly what is new and important in a ground breaking theoretical article.	.414	.646
Translate user needs into requirements for a design so well that users will like the outcome.	.526	.563

\* Values under .4 not considered.

Rotation Method: Varimax with Kaiser Normalisation. Component I captures 34.3% of the variance, component II captures 29.9%, and the total variance explained is 64.7%.

Pairwise factor analysis is used to avoid the deletion of individuals less confident in their views, believed to be a potential source of bias. Repeated analysis using Listwise selection yields an almost identical result. The criteria used for selecting an item are that it must be .6 or higher on its primary component, and less than .4 on any other component. The .4 criterion is used to establish measures that minimise items with shared variance to strengthen the identification of separate self-efficacy concepts.

When the items with bold component scores are tested for their reliability as a scale, the Cronbach's alpha for the seven venturing items is .907, and the alpha for the four technology-related tasks is .866. Deletion of any item from either scale reduces the alpha coefficient.

**Table 2 - Levels of Perceived Self-efficacy by Type of Work Experience**

Type of work experience	Perceived self-efficacy for venturing		Perceived self-efficacy for technology applications	
No work experience in prior year	50.7%	84	53.1%	88
University or some other educational organisation	51.8%	22	52.9%	23
National, regional or local authorities charities or other public organisations	54.1%	44	53.8%	47
Industry or business organisations	52.5%	248	55.4%	249
Total	51.8%	398	54.1%	407

**Table 3 - Types of Work and Background Factors Related to Self-efficacy**

	Sandwich placement	Summer placement	Part-time work	Men	Father runs own business	Strathclyde University
Venturing self-efficacy	.047 (248)	.076 (248)	-.003 (248)	.178** (248)	.189** (245)	.017 (248)
Technology application self-efficacy	-.039 (249)	.066 (249)	-.072 (249)	.259*** (249)	.116 (246)	-.078 (249)

**Table 4 - Relationships among Industry Work Factors and Self-efficacy**

	A	B	C	D	E	F	G	H
A. Shown how group fits in company	---							
	(254)							
B. Rotated through departments	.127*	---						
	(254)	(254)						
C. Authenticity: close to course of study	.045	.218***	---					
	(253)	(253)	(255)					
D. Difficulty of work that was performed	.013	.134*	.514***	---				
	(252)	(252)	(253)	(254)				
E. How well the work was performed	.076	.006	-.147*	-.199***	---			
	(252)	(252)	(253)	(254)	(254)			
F. Received comment about performance	.218***	.132*	.175**	.233***	.119	---		
	(253)	(253)	(253)	(255)	(252)	(254)		
G. Observed someone effective (role model)	.112	.105	.233***	.263***	.027	.172**	---	
	(254)	(254)	(255)	(254)	(254)	(254)	(256)	
H. Talked frequently with role model	.014	.105	.214***	.279***	.012	.100	.878***	---
	(254)	(254)	(255)	(254)	(254)	(254)	(256)	(256)
<u>Self-efficacy</u>								
I. For venturing	.167**	.153*	.218***	.108	.139*	.176**	.124	.129*
	(246)	(246)	(247)	(246)	(246)	(246)	(248)	(248)
J. For technology applications	.019	.178**	.300***	.210***	.074	.142*	.127*	.095
	(247)	(247)	(248)	(248)	(248)	(247)	(249)	(249)

The two types of self-efficacy correlate  $r = .595$  ( $N=242$ ).

**Table 5 - Stepwise Regression Analysis for Venturing Self-efficacy**

<b>Model 1: Background factors</b>	<b>A. Test for Independent Effects</b>			<b>B. Fitted Model</b>		
	b	Beta	T	B	Beta	t
(Constant)	27.259		11.010***	27.259		11.010***
Men	4.813	.172	2.729**	4.813	.172	2.729**
Father runs own business	4.299	.183	2.905**	4.299	.183	2.905**
Statistics for first step model	df = 2, 236; F=8.476, p < .001; multiple R = .259, R <sup>2</sup> = 6.7%			Df = 2, 236; F=8.476, p < .001; multiple R = .259, R <sup>2</sup> = 6.7%		
<b>Model 2: With industry factors</b>	b	Beta	T	B	Beta	t
(Constant)	1.509		0.258	3.027		0.545
Men	4.043	.144	2.381*	4.174	.149	2.479*
Father runs own business	4.626	.197	3.256***	4.639	.197	3.284**
How group fits in company	2.860	.123	1.954 <sup>◇</sup>	2.888	.124	2.021*
Rotated through departments	1.851	.078	1.262			
Authentic, close to studies	2.197	.176	2.412*	2.330	.186	2.939**
Difficulty of work performed	-0.022	-.002	-0.027			
How well work was performed	2.430	.147	2.342*	2.467	.149	2.436*
Comments about performance	2.687	.115	1.770 <sup>◇</sup>	2.712	.116	1.852 <sup>◇</sup>
Saw someone effective	-1.399	-.057	-0.455			
Often talked with that person	.967	.117	0.943	.597	.072	1.170
Change statistics for second step model	R <sup>2</sup> change = 11.9%; df = 8, 228, F change = 4.148, p < .001			R <sup>2</sup> change = 11.2%; df = 5, 231, F change = 6.304, p < .001		
Statistics for full model	df = 10, 228; F=5.195, p < .001; multiple R = .431, R <sup>2</sup> = 18.6%			Df = 7, 231; F=7.197, p < .001; multiple R = .423, R <sup>2</sup> = 17.9%		

<sup>◇</sup> p < .10, \* p < .05, \*\*p < .01, \*\*\*p < .001.



**Table 6 - Stepwise Regression Analysis for Technology Applications Self-efficacy**

Model 1: Background factors	C. Test for Independent Effects			D. Fitted Model		
	B	Beta	t	B	Beta	t
(Constant)	17.515		12.782***	17.450		12.777***
Men	3.862	.242	3.855***	3.878	.243	3.876***
Father runs own business	1.146	.086	1.370	1.198	.090	1.440
Statistics for first step model	df = 2, 238; F = 8.958, p < .001; multiple R = .265, R <sup>2</sup> = 7.0%			df = 2, 239; F = 9.185, p < .001; multiple R = .267, R <sup>2</sup> = 7.1%		
Model 2: With industry factors	B	Beta	t	b	Beta	t
(Constant)	6.012		1.876	6.477		2.105*
Men	3.777	.237	3.963***	3.602	.226	3.808***
Father runs own business	1.220	.092	1.539	1.173	.088	1.492
How group fits in company	-.725	-.056	-0.904			
Rotated through departments	1.330	.100	1.633	1.418	.106	1.763 <sup>◇</sup>
Authentic, close to studies	1.458	.209	2.905**	1.566	.225	3.155**
Difficulty of work performed	.664	.113	1.533	.748	.127	1.810 <sup>◇</sup>
How well work was performed	1.052	.114	1.838 <sup>◇</sup>	1.113	.121	2.004*
Comments about performance	.848	.064	1.011			
Saw someone effective	2.413	.178	1.423			
Often talked with that person	-.586	-.127	-1.031			
Change statistics for second step model	R <sup>2</sup> change = 13.6%; df = 8, 230; F change = 4.946; p < .001			R <sup>2</sup> change = 12.1%; df = 4, 235; F change = 8.841; p < .001		
Statistics for full model	df = 10, 230; F = 5.986, p < .001; multiple R = .454, R <sup>2</sup> = 20.7%			df = 6, 235; F = 9.358, p < .001; multiple R = .439, R <sup>2</sup> = 19.3%		

<sup>◇</sup> p < .10, \* p < .05, \*\*p < .01, \*\*\*p < .001.

Variable “Saw someone effective” was excluded from Model D2 after the calculation of an interim model made first without “Comments” and “Often talked” (not shown) showed a drop in “Saw someone effective” to beta = .072, sig. level at .245. The variable “Father runs own business” is retained for comparability with other models.

Minor differences appear in the first step because listwise regression is used, and removing variables with missing data increases the N and degrees of freedom.